

Orbital detections of water in crystalline plagioclase and olivine on the lunar surface: Insights into magma ocean water

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Water may have been enriched in the KREEP layer situated between the crust and mantle during the solidification of the lunar magma ocean if the Moon was not completely depleted in water during its formation. Minerals associated with the KREEP layer may show enrichment in incompatible elements and water, and can be brought to the lunar surface by impact or intrusion. Minerals exposed on the lunar surface are heavily space weathered by solar wind, micrometeoroid bombardment, and cosmic rays and eventually lose their crystalline structures. In other words, crystalline minerals exposed on the lunar surface should have been much less weathered and may have preserved the record of their formation conditions. Pure crystalline plagioclase and mantle olivine exposures were reported in previous studies. We examined the water content of these pure crystalline plagioclase and olivine locations using the spectral band near 3 μm of the Moon Mineralogy Mapper (M^3) data. The crystalline plagioclase exposures are mostly associated with the inner ring of multi-ring basins and may originate from the lower crust. The olivine rich materials are mostly associated with large basins and were interpreted as being sourced from the upper mantle. Our preliminary results show that the water content of these plagioclase and olivine shows a wide range from 0 ppm to 50 ppm above the background value (2 standard deviations above the mean value of the global water content at specific latitude). Although previous studies show that crystalline minerals exhibit higher efficiency at adsorbing water than glasses, the surface adsorbed water is not stable at the local noon at the low latitude. Our analyses are based on the M^3 data acquired during the local noon and focus on the latitude less than 40° N/S, which may avoid the possibility that the 'excess' water observed in these crystalline minerals is due to their stronger surface adsorption of water. We interpret that the wide range of water in plagioclase and olivine may represent water from the lunar magma ocean. There might be water-bearing minerals (e.g., apatite) associated with these minerals that were brought to the surface by impact. For instance, the water content measured from apatite in lunar samples ranges from 100s ppm to 10,000 ppm. Approximately 0.5% of apatite in these plagioclase and olivine is sufficient to explain their wide range of water content (0 – 50 ppm above the background).